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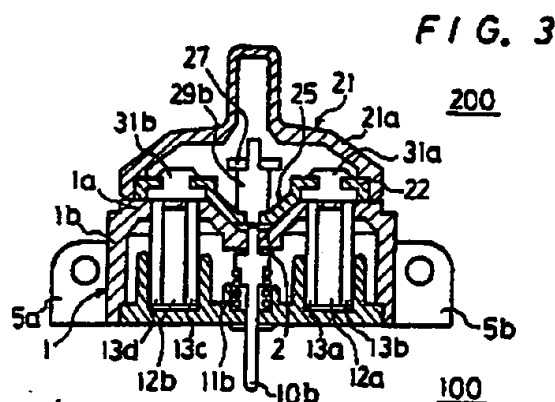
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(64) **Electrical connector.**

(67) An electrical connector apparatus has a connector socket (100) and a connector plug (200) which can co-operate so that electrical contacts (10) of the connector socket (100) engage respective electrical contacts (29) of the plug (200) and the connector socket (110) and the connector plug (200) are kept in engagement with each other by magnetic force (12, 31), whereby when unintentional tension is applied to a cord coupled to the plug (100), the cord will not be broken since the connector socket (100) and the connector plug (200) can be easily disengaged from each other.



EP 0 289 208 A2

## ELECTRICAL CONNECTOR

The invention relates generally to an electrical connector and particularly though not exclusively to an electrical connector for coupling headphones to audio equipment.

Various electrical connectors have been proposed to interconnect audio equipment. As is disclosed in greater detail, for example, in Japanese Published Utility Model Application No. 60-29833, usually the connector is formed with a connector plug which can be inserted into a connector socket (jack). When the connector plug is inserted into the connector socket, the connector plug is held by spring members of contacts of the connector socket.

In such a conventional connector, when unintentional tension is applied in the axial direction of the cord, the connector plug is pulled out of the connector socket. If, however, the tension is applied in a direction perpendicular to the axial direction of the cord and the connector plug, the connector plug will not be pulled out of the connector socket. In this case the cord may be broken or the user's head may be injured by a headphone attached to the cord.

According to one aspect of the invention there is provided an electrical connector comprising a connector socket and a mating connector plug comprising:

a) a plurality of first signal terminals mounted in one of the plug and the socket; and

b) a plurality of second signal terminals to co-operate with the first signal terminals and mounted in the other of the plug and the socket; and characterised by magnetic means for coupling the plug to the socket in such a manner that the plurality of first signal terminals and the plurality of second signal terminals contact one another.

In such a connector the connector plug can easily be removed from the connector socket when an unintentional tension is applied to a cord. If the cord is a headphone cord it will not be broken and injury to the user from the headphone will be avoided.

In the preferred embodiment the plug comprises a first housing having a first contact face and a convex or a concave portion formed on the first contact face. A plurality of leads are accommodated in the first housing and a plurality of the first terminals, each connected to one end to a separate one of the plurality of leads, are accommodated in the first housing and exposed to the outside at their other ends at one of the convex and concave portions. A pair of metal plates are located at opposite sides of one of the convex and concave portions.

The socket comprises a second housing having a second contact face and a co-operating convex or concave portion formed on the second contact face. A plurality of second terminals are accommodated in the second housing and each is exposed at one end to the outside at the other of the convex and concave portions. A pair of metal plates are located at opposite sides of the other of the convex and concave portions on the second contact face and magnetic means contact the pair of metal plates.

According to another aspect of the invention there is provided an electrical connector characterised by:

a) a plug including a first housing having a first contact face and a first mating portion formed on the first contact face, a plurality of electrical leads, a plurality of first terminals which are connected each at one end to a respective one of the plurality of electrical leads, wherein the terminals are accommodated in the first housing and exposed to the outside of the first housing at their other ends at the first mating portion, and first magnetic coupling means located at opposite sides of the first mating portion; and

b) a socket including a second housing having a second contact face and a second mating portion formed on the second contact face, a plurality of second terminals accommodated in the second housing and each exposed at one end to the outside of the second housing at the second mating portion, and second magnetic coupling means located at opposite sides of the second mating portion on the second contact face.

The invention is diagrammatically illustrated by way of example in the accompanying drawings, in which:-

Figures 1A - 1E show a connector socket of an electrical connector according to the invention, wherein Figure 1A is a plan view, Figure 1B is a bottom view, Figure 1C is a right side view, Figure 1D is a cross-sectional view, with portions in elevation, taken generally on line a-a of Figure 1A and Figure 1E is a cross-sectional view, with portions in elevation, taken generally on line b-b of Figure 1A;

Figures 2A - 2E shows a connector plug of an electrical connector according to the invention, wherein Figure 2A is a plan view, Figure 2B is a front view, Figure 2C is a bottom view, Figure 2D is a cross-sectional view, with portions in elevation, taken generally on line c-c of Figure 2A and Figure 2E is a cross-sectional view, with portions in elevation, taken generally on line d-d of Figure 2A;

Figures 3 and 4 are vertical sectional views, with portions in elevation, of an assembled electrical connector;

Figure 5 shows an electrical connector of the invention in use; and

Figures 6A to 6E are diagrams showing examples of modifications of an electrical connector according to the invention.

Referring to the drawings and firstly to Figures 1A to 1E, a connector socket 200 of an electrical connector has a cup-shaped housing 1 formed with an end wall 1a and a cylindrical wall portion 1b. The housing 1 can be made of, for example, ABS (acrylonitrile-butadiene-styrene copolymer) resin. A rectangular-shaped concave recess 2 is formed in the end wall 1a of this housing 1 at its centre. The concave recess 2 has four side walls 2a, 2b, 2c and 2d, each of which is formed to have a predetermined inclination. In this case, as shown in Figure 1E, the side wall 2d of the short side has an inclination smaller than that of the other opposing side wall 2b. Three circular openings 3a, 3b, and 3c are formed through a bottom 2e of the concave recess 2 along its longitudinal direction as shown in Figure 1A. A first pair of rectangular-shaped openings 4a, 4b are aligned through the end wall 1a with the long side wall 2a of the concave recess 2 and are spaced therefrom as shown in Figure 1A. Similarly, a second pair of rectangular-shaped openings 4c, 4d are aligned through the end wall 1a with the long side wall 2c of the concave recess 2 and are spaced therefrom as shown in Figure 1A.

A pair of projecting lugs 5a, 5b, each having a circular opening are integrally formed with the cylindrical wall 1b of the housing 1 as shown in Figure 1C. The lugs 5a, 5b can be used to secure the housing 1 to a panel or housing of an acoustic appliance. As best shown in Figure 1E, projecting from the inner face of the end wall 1a are a pair of rod-shaped protrusions 6a, 6b. They extend downward, as shown in Figure 1E.

A disc-shaped lid 7 made of, for example, ABS resin, is engaged into a stepped portion formed at the open end of the cup-shaped housing 1 as shown in Figure 1B, 1D and 1E. Circular openings 8a, 8b are formed through the lid 7 in alignment with the pair of protrusions 6a, 6b formed in the housing 1, as shown in Figure 1E. When the lid 7 is engaged into the stepped portion formed at the open end of the housing 1, the protrusions 6a, 6b enter the openings 8a, 8b and heads of the protrusions 6a, 6b protruding beyond the lid 7 are flattened to be larger than the diameters of the openings 8a, 8b. Thus, the lid 7 is effectively riveted to the housing 1.

Circular openings 9a, 9b and 9c are formed through the lid 7 in alignment with the openings 3a to 3c formed through the concave recess 2 of the

housing 1. As shown in Figure 1E, seated in the openings 9a to 9c are pins 10a to 10c made of, for example, brass plated with nickel and gold so as to prevent corrosion. The diameters of central portions of the pins 10a to 10c are selected to be larger than those of the openings 3a to 3c formed through the housing 1 and those of the openings 9a to 9c formed through the lid 7. Also, the pins 10a to 10c have at their sides near the openings 3a to 3c flanges which are larger in diameter than the diameters of centre portions of the pins 10a to 10c, and the portions thereof are selected to be smaller than those of the openings 3a to 3c and 9a to 9c. One end of each of the pins 10a to 10c is engaged through the openings 3a to 3c of the housing 1, while the other ends thereof are engaged through the openings 9a to 9c of the lid 7. Springs 11a to 11c are provided between the flanges of the pins 10a to 10c and the lid 7, whereby the pins 10a to 10c are resiliently movable from the positions illustrated in Figure 1E towards the lid 7. At the same time, the pins 10a to 10c are spring-biased towards the end wall 1a of the housing 1 so as to be returned to the positions illustrated in Figure 1E. By way of example, one end of each of the pins 10a, 10b and 10c protrudes from the end wall 1a from the openings 3a, 3b and 3c formed through the housing 1. These pin ends serve, respectively, as the right audio signal contact, earth contact and left audio signal contact for a passenger entertainment system, for example, which is to be understood as being connected to the pins 10a to 10c, although not shown.

As illustrated in Figure 1D, magnets 12a, 12b are respectively located between the openings 4a, 4b and 4c, 4d in a cavity in the housing formed between the end wall 1a of the housing 1 and the lid 7. Magnetic plates 13a, 13b, made of iron plated with nickel, are mounted on opposite sides of the magnet 12a. The upper end portions of the magnetic plates 13a, 13b are engaged in the openings 4a, 4b and protrude from the upper surface of the housing 1. Similarly, magnetic plates 13c, 13d, made of iron plated with nickel, are mounted on opposite sides of the magnet 12b. The upper end portions of the magnetic plates 13c, 13d are engaged in the openings 4c, 4d and protrude from the upper surface of the housing 1.

Figure 2 illustrates a connector plug 200 which, together with the socket of Figures 1A to 1E, forms an electrical connector.

Referring to Figures 2A to 2E, there is provided a housing 21 having a terminal compartment portion 21a, in the shape of a circular truncated cone, and a cylindrically-shaped cord compartment portion 21b. The housing 21 is made of, for example, ABS resin. A disc-shaped lid 22 is made of, for example, ABS resin and a plurality of extensions

23 are formed around the outer peripheral portion of the lid 22 as shown in Figure 2E. These extensions are engaged with a plurality of grooves 24 formed around the mouth of the terminal compartment portion 21a whereby the lid 22 is fixed to the housing 21. At the centre of the lid 22, there is formed a convex portion 25 which can engage in the concave recess 2 formed at the centre of the end wall 1a of the housing 1. The convex portion 25 is formed with four side walls 25a, 25b, 25c and 25d, each having a predetermined inclination. As shown in Figures 2B and 2C, the angle of inclination of one short wide wall 25d is selected to be smaller than that of the other or opposing side wall 25b. Thus the mating portions of the plug and the socket are each in the shape of a truncated pyramid but with one side of the pyramid having a different angle of inclination to all of the other sides.

Three circular openings 28a, 28b and 28c are formed through a bottom 25e of the convex portion 25 along the longitudinal direction thereof. A base plate 27 is mounted within the terminal compartment portion 21a, and circular openings 28a, 28b and 28c are formed through the base plate 27 in alignment with the openings 28a to 28c formed through the lid 22.

A set of terminals 29a, 29b and 29c are each made of, for example, brass plated with nickel and gold so as to prevent corrosion. The terminals 29a to 29c each have central portion which is larger in diameter than the inner diameters of the openings 28a to 28c and 28a to 28c and end portions near the lid 22 and the base plate 27 which are smaller in diameter than the inner diameters of the openings 28a to 28c and 28a to 28c. One end of each of the terminals 29a to 29c is engaged in a respective one of the openings 28a to 28c of the base plate 27 to its outside. In this case, the terminals 29a, 29b and 29c are used as a right audio signal contact, an earth contact and a left audio signal contact, respectively.

Alongside and radially outward from the long side portions 25a, 25c of the convex portion 25 of the lid 22, there are formed circular openings 30a and 30b, respectively, as shown in Figures 2C and 2D. These openings 30a and 30b are arranged to be stepped and the lower portions thereof, as viewed in Figure 2D, are made larger in diameter. Into the openings 30a and 30b, there are inserted stepped-shaped plates 31a, 31b formed to correspond in shape to the openings 30a and 30b. The plates 31a, 31b are each made of, for example, iron which is plated with nickel. The portions of the plates 31a, 31b which protrude to the upper surface side of the lid 22, as viewed in Figure 2D, are spread out so as to be larger than the inner diameters of the openings 30a, 30b, thereby secur-

ing the plates 31a and 31b to the lid 22.

The connector plug 200 further includes a bushing 32 made of, for example, vinyl chloride, a cord 33 and a cord support member 34. Separate lead wires 33a, 33b and 33c led from the cord 33 are soldered, respectively, to the terminals 29a to 29c that protrude from the base plate 27. To the other end of the cord 33, there is connected, for example, a headphone (not shown).

In this embodiment, the connector socket 100 and the connector plug 200 are formed as described above. In operation, when the connector plug 200 is coupled to the connector socket 100, as shown in Figures 3 and 4, the concave recess 2 formed at the centre of the end wall 1a of the housing 1 of the connector socket 100 receives the convex portion 25 formed at the centre of the lid 22 of the connector plug 200.

In this case, as shown in Figure 3, the plates 31a, 31b fixed to the lid 22 of the connector plug 200 respectively contact the upper end portions of the magnetic plates 13a, 13b, 13c and 13d protruding from the end wall 1a of the housing 1 of the connector socket 100 so that the connector plug 200 is held in the engaged state with the connector socket 100 by magnetic force.

Further, in this case, as shown in Figure 4, the pins 10a to 10c extend to the concave recess 2 of the housing 1 of the connector socket 100 and contact the terminals 29a to 29c, respectively, provided at the surface of the lid 22 of the connector plug 200 so that conductive connections between them are established. Upon connection of the parts 100 and 200 as above described, the pins 10a to 10c are forced back into the housing 1 and are urged against the terminals 29a to 29c by the forces of the springs 11a to 11c and contact therewith positively.

In accordance with this embodiment, as described hereinabove, when the connector plug 200 is coupled to the connector socket 100, they are kept in contact with each other by magnetic force so that the connector plug 200 can easily be removed from the connector socket 100 if unintentional tension is applied to the cord 33. In addition, according to this embodiment, since the side walls 2a to 2d of the concave recess 2 of the connector socket 100 and the side walls 25a to 25d of the convex portion 25 of the connector plug 200 are formed to have the predetermined inclinations, the connector plug 200 can easily be removed from the connector socket 100 by tension applied in the axial direction of the cord 33. Further, since the connector plug 200 has the cord compartment portion 21b extending in the axial direction of the cord 33, by lever action the connector plug 200 is disengaged from the connector socket 100 even if only a slight tension is applied in a direction per-

pendicular to the axial direction of the cord 33. Thus the connector plug 200 can easily be removed from the connector socket 100 regardless of the direction in which the tension is applied. Therefore there is no risk of the cord 33 being broken and also a user wearing a headphone connected to the cord will not have his head injured.

Further, according to this embodiment, since one side wall 2d of the short side of the concave portion 2 of the connector socket 100 has an inclination smaller than that of the other side wall 2b and one side wall 25d of the short side of the convex portion 25 of the connector plug 200 has an inclination smaller than that of the other side wall 25b in correspondence therewith, the direction in which the connector plug 200 is coupled to the connector socket 100 is uniformly determined. Thus, the left and right audio signals are prevented from being supplied to the headphone in the reverse order.

Furthermore since the connector plug 200 is coupled to the connector socket 100 without friction, unlike a conventional socket system, there is then the advantage that the connector plug 200 can be coupled to and/or removed from the connector socket 100 with ease.

The connector is suitable for use in a passenger entertainment system, as for example, shown in Figure 5, where connector sockets 100 are provided at each of the passenger seats of a passenger vehicle such as an aircraft, train or bus and can easily be connected with connector plugs 200 connected to headphones 50. In Figure 5, reference 51 designates a display apparatus and 52 a control panel.

In the above-mentioned embodiment, the positions of the pins 10a to 10c and the magnetic plates 13a to 13d of the connector socket 100 and the positions of the terminals 29a to 29d and the plates 31a to 31b of the connector plug 200 may be reversed, respectively. Further, the number of the pins and terminals are not limited to sets of three but can be selected to be any desired number.

In the above embodiment, as shown in Figures 6A and 6B, the plates 31a and 31b provided at the connector plug 200, can be replaced by a pair of magnets 41 gripped by magnetic plates 42a, 42b, and having opposite magnetic polarity to the magnets 12a and 12b. Further, as shown in Figure 6C, a strong magnet 43 such as alnico (aluminium nickel-cobalt alloy) may directly be used in the connector socket 100. In this case, as shown in Figure 6D, a similar magnet 44 may be provided in the connector plug 200. According to the examples shown in Figures 6C and 6D, the magnetic flux extends to a greater distance from the plug 100 and the socket 200 so that the attractive force acts

from a greater distance. Magnets such as ferrite, samarium and cobalt may be utilised similarly although the magnetic coupling force is slightly weakened.

When the connector apparatus employs a magnet constructed as shown in Figure 6D, a reverse connection is also prevented by choosing the polarities of the magnets 43a, 43b and 44a, 44b of the connector socket 100 and the connector plug 200 as shown in Figure 6E to be opposite. An attempt incorrectly to mate the plug 100 with the socket 200 will be repelled by the force of the magnets.

Further, unlike the above-mentioned embodiment, the electrical connector can be formed to use the magnet portion as the electrode portion and vice versa.

Furthermore, while an electrical connector is described above used for a headphone, the invention is not limited to such an application but can be used as a connector for other uses such as outdoor audio equipment, e.g. portable tape players.

## Claims

1. An electrical connector comprising a connector socket (100) and a mating connector plug (200) comprising:

a) a plurality of first signal terminals (10a, 10b, 10c) mounted in one of the plug (200) and the socket (100); and

b) a plurality of second signal terminals (29a, 29b, 29c) to co-operate with the first signal terminals and mounted in the other of the plug (200) and the socket (100); and

characterised by magnetic means (12a, 12b, 31a, 31b) for coupling the plug (200) to the socket (100) in such a manner that the plurality of first signal terminals and the plurality of second signal terminals contact one another.

2. An electrical connector according to claim 1, wherein the plug (200) includes a contact face having a convex portion (25) and the socket (100) includes a contact face having a concave recess (2) which is shaped to mate with the convex portion of the plug.

3. An electrical connector according to claim 1, wherein the plug includes a contact face having a concave portion and the socket includes a contact face having a convex portion which is shaped to mate with the concave portion of the plug.

4. An electrical connector according to claim 2 to claim 3, wherein the plurality of first signal terminals are provided in one of the convex portion (25) and the concave recess (2) and the plurality of second signal terminals are provided in the other of the convex portion and the concave recess.

5. An electrical connector according to claim 1, wherein the magnetic means comprises a first magnet (12a) mounted in one of the plug and the socket and magnetic material (28a; 41) mounted in the other of the plug and the socket, the first magnet and the magnetic material being mounted in such a way that when the plug and socket are mated, the first magnet and the magnetic material are magnetically coupled to each other thereby to exert an attractive, magnetic force on one another.

6. An electrical connector according to claim 5, wherein the magnetic material is a second magnet (41) arranged so that its magnetic poles mate with the opposite magnetic poles of the first magnet (12a) when the plug and socket are mated.

7. An electrical connector according to any one of claims 2 to 4, wherein the magnetic means comprises a pair of magnets (12a, 12b) which are located at opposite sides of one of the convex portion and the concave recess and a pair of ferrous metal plates (31a, 31b) which are located at opposite sides of the other of the convex portion and the concave recess.

8. An electrical connector according to any one of claims 1 to 7, wherein one of the plurality of first and second signal terminals are pin-shaped terminals (10a, 10b, 10c) and further including springs (11a, 11b, 11c) for resiliently supporting the terminals.

9. An electrical connector according to any one of claims 1 to 8, wherein the plug (200) is connected at its free end to a headphone (50).

10. An electrical connector according to claim 9, wherein the headphone (50) is a stereo headphone and a plurality of first signal terminals and said plurality of second signal terminals include left and right terminals for stereo and an earth terminal, respectively.

11. An electrical connector characterised by:

a) a plug (200) including a first housing (21) having a first contact face and a first mating portion (25) formed on the first contact face, a plurality of electrical leads (33a, 33b, 33c), a plurality of first terminals (31a, 31b, 31c) which are connected each at one end to a respective one of the plurality of electrical leads, wherein the terminals are accommodated in the first housing and exposed to the outside of the first housing at their other ends at the first mating portion, and first magnetic coupling means (31a, 31b) located at opposite sides of the first mating portion; and

b) a socket (100) including a second housing (1) having a second contact face and a second mating (2) portion formed on the second contact face, a plurality of second terminals (10a, 10b, 10c) accommodated in the second housing (1) and each exposed at one end to the outside of the second housing at the second mating portion, and

second magnetic coupling means (12a, 12b) located at opposite sides of the second mating portion (2) on the second contact face.

12. An electrical connector according to claim 11, wherein said first and second mating portions are convex and concave shaped, respectively.

13. An electrical connector according to claim 11, wherein said first and second mating portions are concave and convex shaped, respectively.

14. An electrical connector according to claim 11, wherein the first and second mating portions are each in the shape of a truncated pyramid but with one side of the pyramid having a different angle of inclination than all of the other sides.

15. An electrical connector according to claim 11, wherein the plug (200) is connected at its free end to a headphone (50).

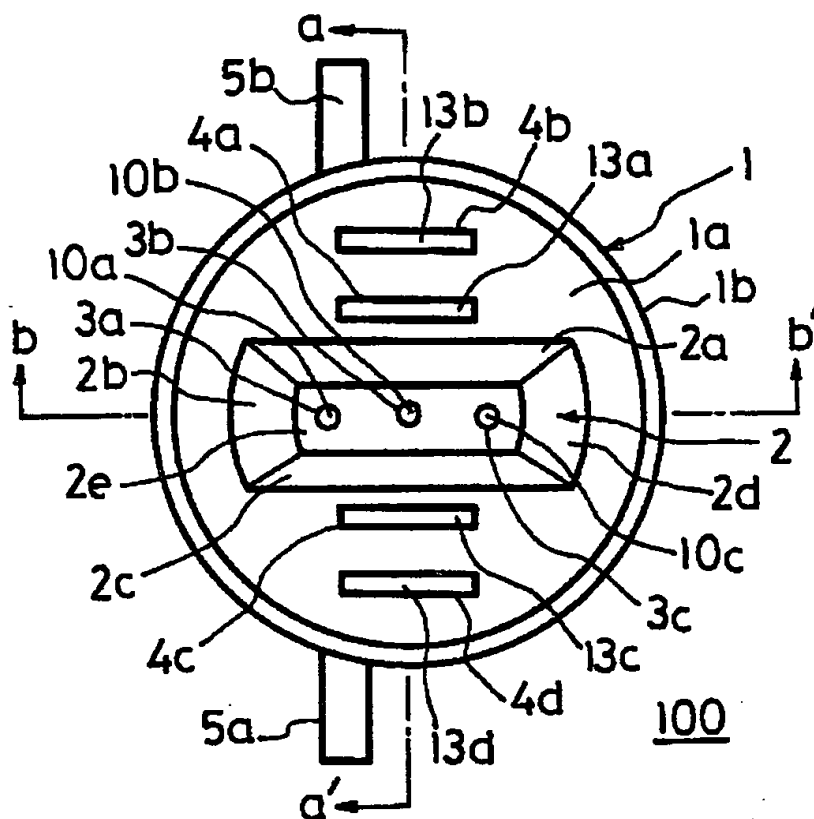
16. An electrical connector according to claim 15, wherein the headphone (50) is a stereo headphone and the plurality of first and second terminals each include left and right terminals for stereo and an earth terminal.

17. An electrical connector according to claim 11, wherein the first housing (21) has a cylindrical cord accommodating section (21b) in which the plurality of electrical leads are accommodated.

18. An electrical connector according to claim 11, further including springs (11a, 11b, 11c) accommodated in the second housing (21) and wherein the plurality of second terminals (10a, 10b, 10c) are restrained for limited, sliding movement within the second housing (100) and are biased by the springs to extend their one ends as far out of the second housing as possible.

19. An electrical connector according to claim 18, wherein said plurality of first and second terminals are each arranged in an in line fashion.

FIG. 1A



**F I G. 1B**

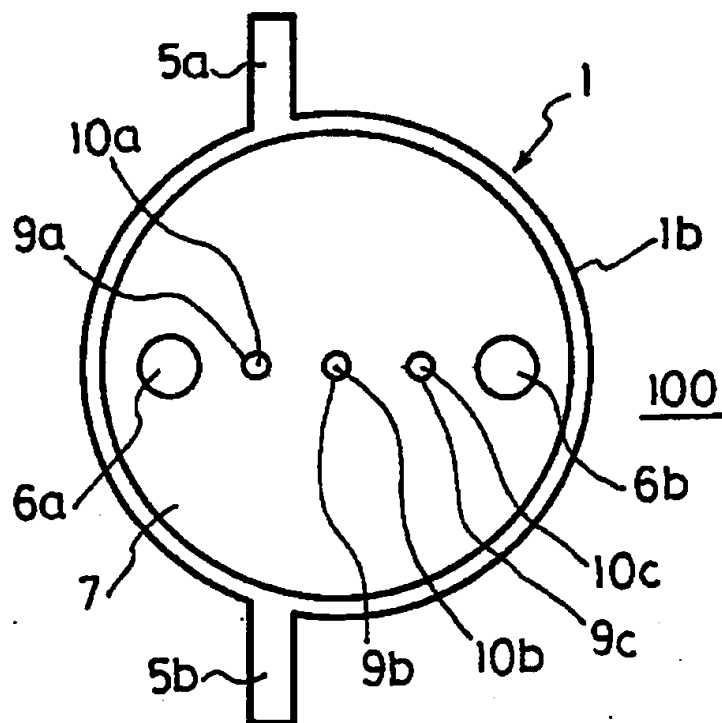


FIG. 1C

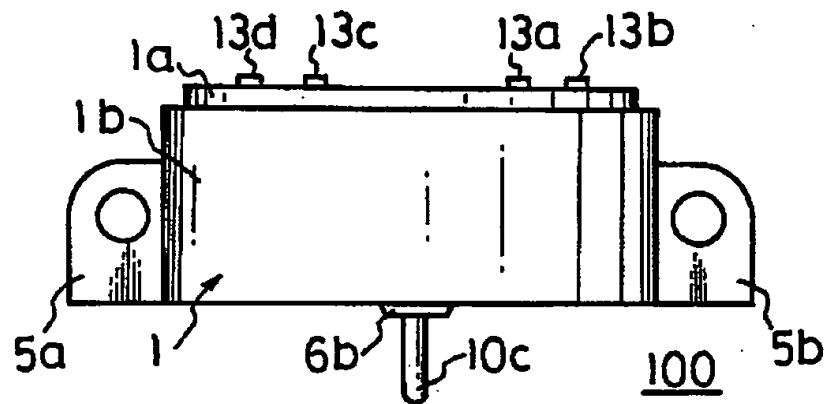


FIG. 1D

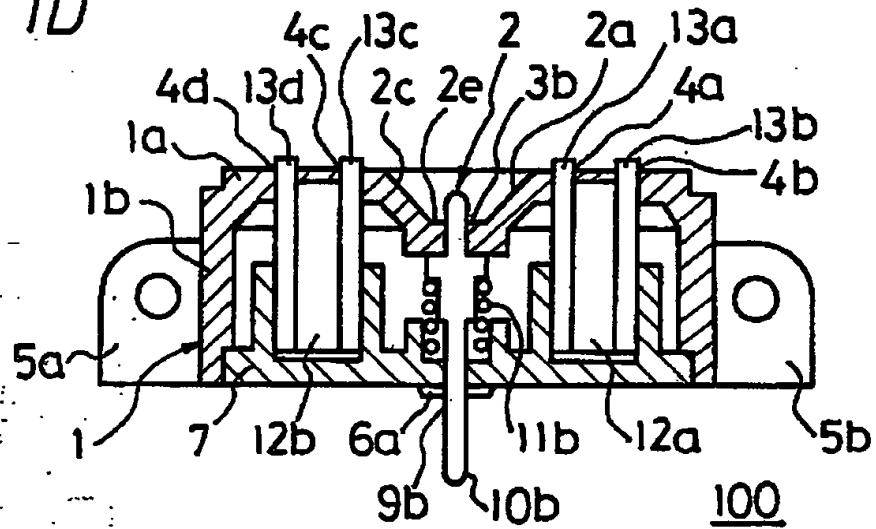
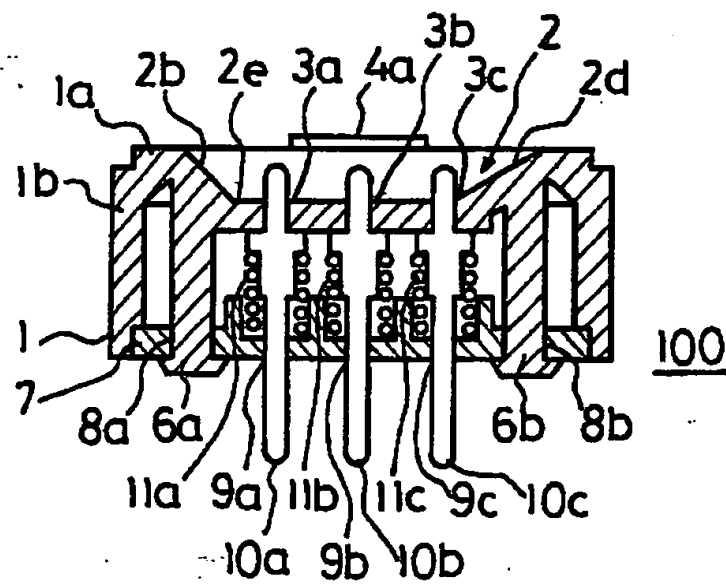


FIG. 1E





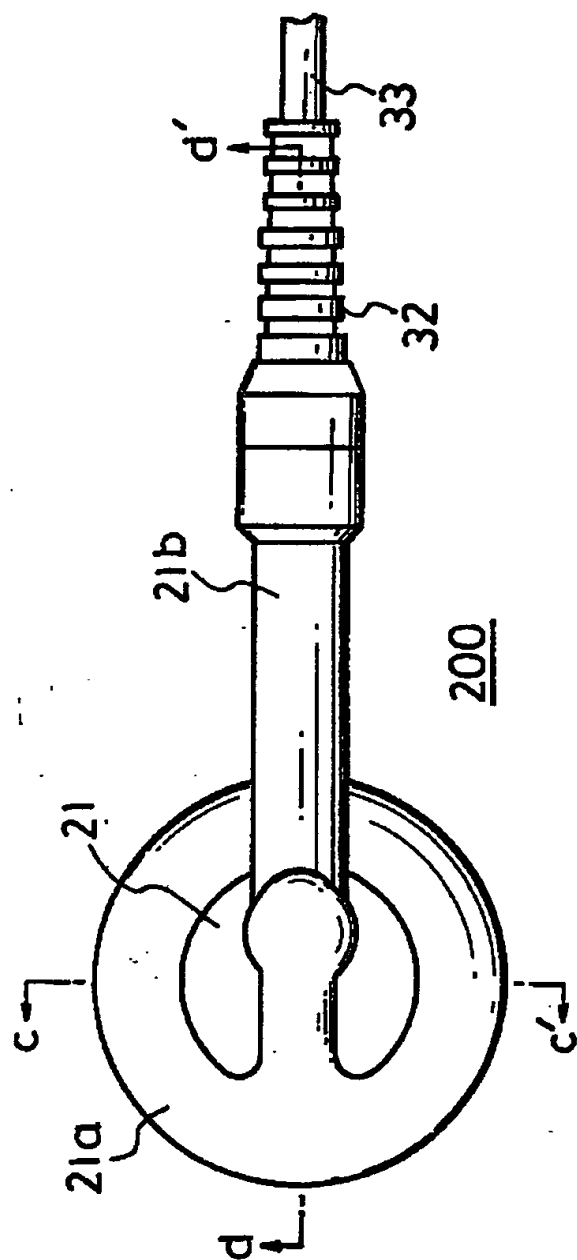
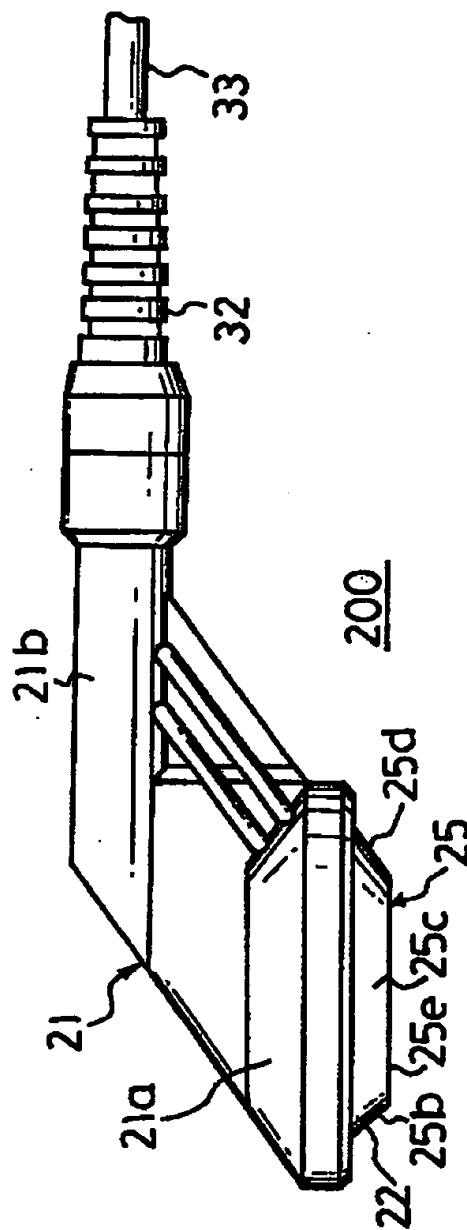


FIG. 2A



**FIG. 2B**

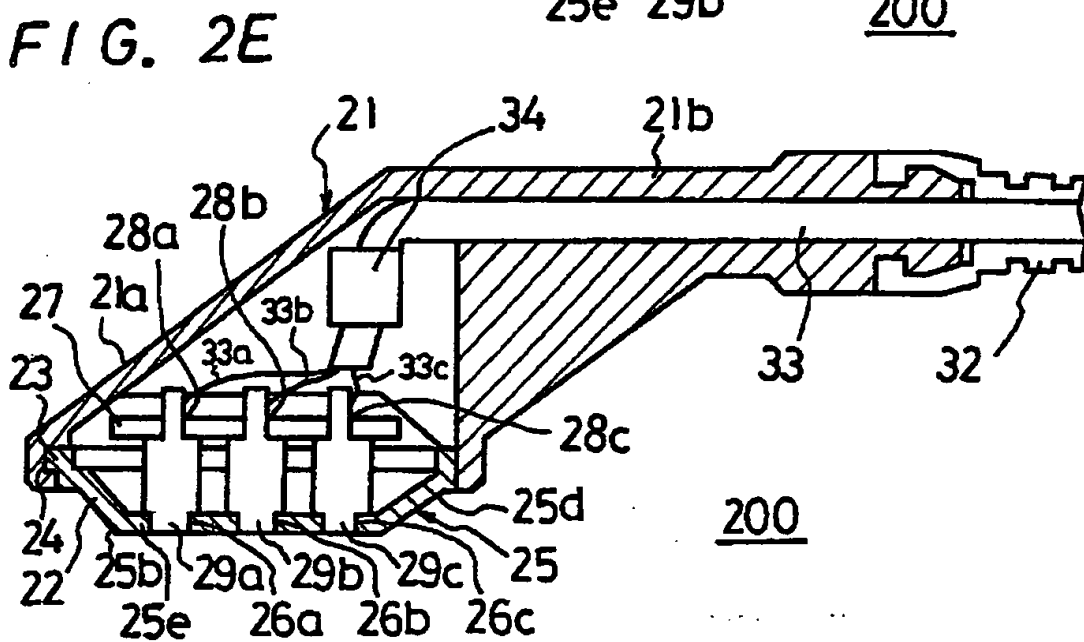
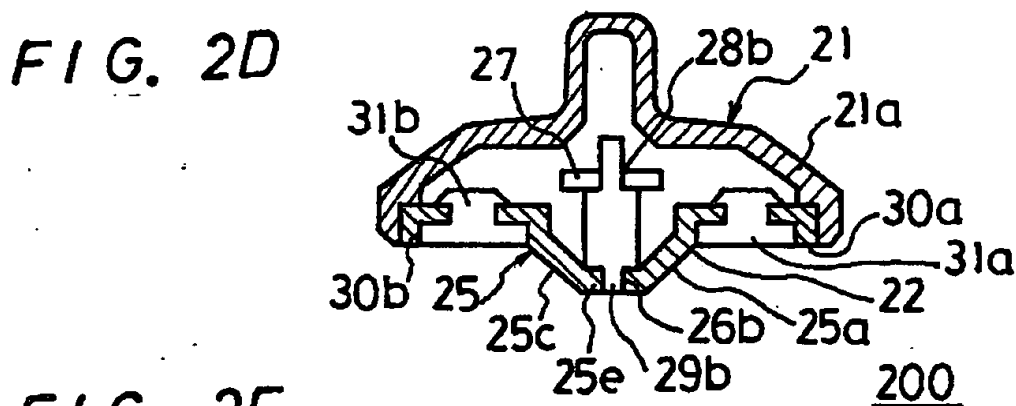
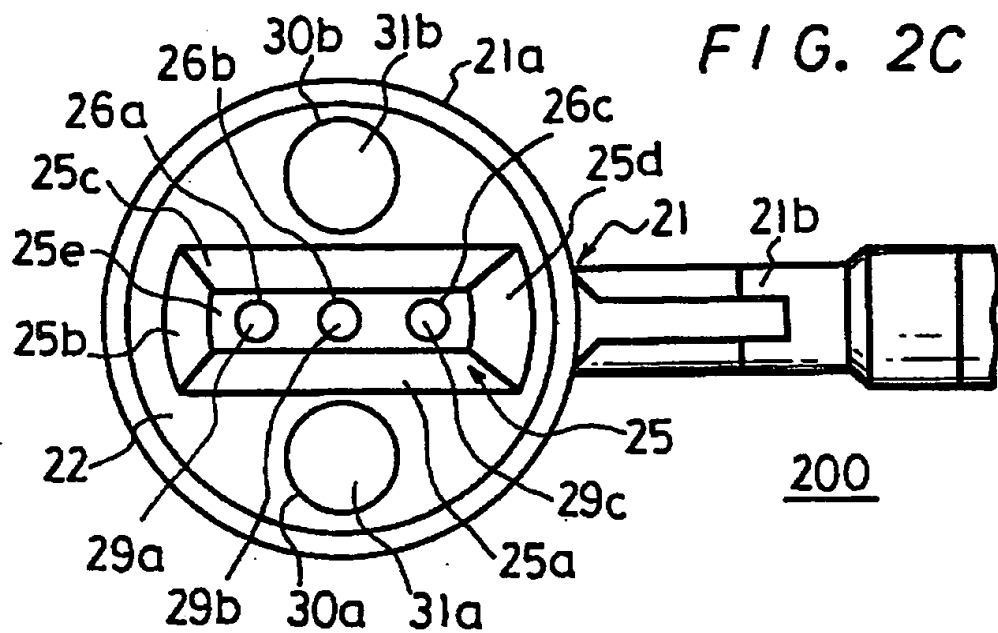


FIG. 3

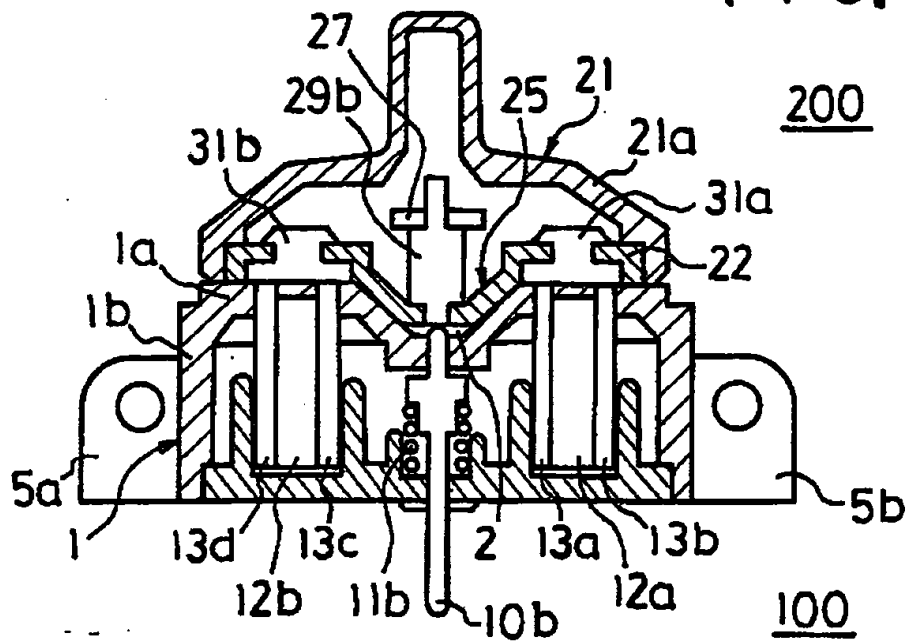


FIG. 5

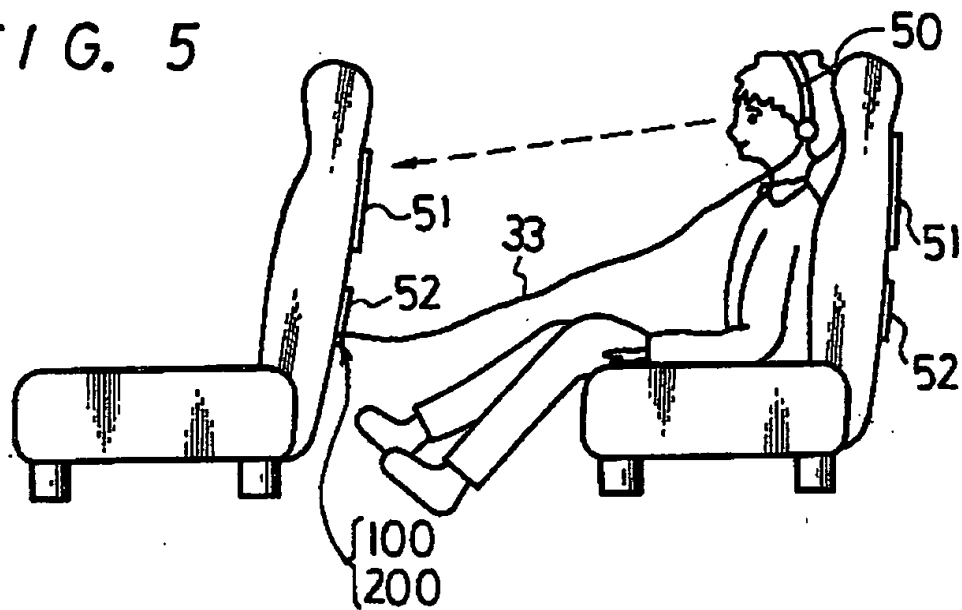


FIG. 6A

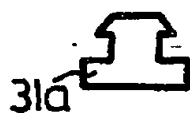


FIG. 6B

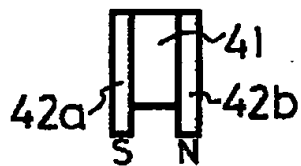


FIG. 6C

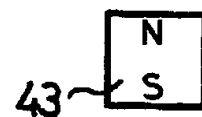
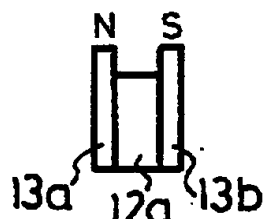
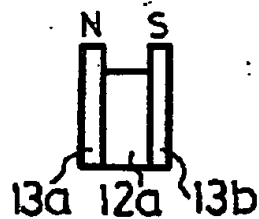


FIG. 6D



FIG. 6E

